Whence these values were originally derived I cannot say. They are unquestionably incorrect, and are, in fact, not even near the true values. This is easily shown in any given case. Thus take the second satellite, whose diameter is a little over 2000 miles, or about $\frac{1}{40}$th part of *Jupiter's* mean diameter. Then, if of equal density with *Jupiter*, its mass would be about $\frac{1}{64000}$th part of *Jupiter's*, or would be represented by 0·0000156. But Laplace's estimate of the mass of this satellite is 0·0000232, or more than half as great again as that resulting from a density only equalling *Jupiter's*. Hence the satellite's density is more than half as great again as *Jupiter's*. But *Jupiter's* density is represented by 0·24 if the Earth's is taken as unity; and by 1·36 if the density of water is taken as unity. Hence this satellite's density would be represented by more than 0·36, if Earth's equal 1, and by more than 2·04 if the density of water = 1.

So much to show that the values tabulated by Lardner and Chambers are erroneous whencesoever obtained.

The following values of the densities of the several satellites have been obtained by combining Laplace's estimates of the mass, with the values of the diameters given in the second column:—

Satellite.	Diameter in Miles.	Density, Earth as 1.	Density, Water as 1.
I	2352	0·198	1·148
II	2099	0·374	2·167
III	3436	0·325	1·883
IV	2926	0·253	1·468

It will be observed that all the satellites except the first thus appear to have a greater mean density than *Jupiter*. Probably their real densities are greater than those here tabulated, since irradiation would increase their apparent diameters.

Note on the Orbit of the Double Star Castor.
By J. M. Wilson, Esq.

The orbit of *Castor* appears to be hyperbolic, a form of orbit which, as far as I am aware, has not been shown to exist in the case of any binary system.* Mr. Gledhill was good enough to furnish me with a list of measures of *Castor*, extending from A.D. 1740 to the present time, and on charting these on a table of

* [It may be interesting to compare with Mr. Wilson's hyperbolic orbit the elliptic orbit deduced by Mr. Hind from all the observations with which he was acquainted, ranging over the period from 1718 to 1845. In the *Monthly Notices* for December 1845, Mr. Hind remarks that "the elements are entirely different from those previously computed by Sir John Herschel and M. Mädler; and this difference is materially owing to the great influence exerted by recent measures at Mr. Bishop's observatory, by Mr. Dawes." The results "are as follows" (we quote from a note by Mr. Dawes in vol. xxxv. of our

engraved squares, and drawing and correcting the interpolating curve according to Herschel's method, I obtain the following eleven points for the determination of the orbit:—

θ.	t.	r.
340	1740·46	11450
330	52·44	10588
320	63·14	10188
310	73·34	10065
300	83·49	10119
290	93·89	10320
280	1804·89	10700
270	16·89	11256
260	30·39	12054
250	46·45	13254
240	66·49	15343

When the points are laid down they lie nearly on a hyperbola of eccentricity 2·2. The real hyperbola may be also shown by a graphical construction to have an eccentricity = 3·16, and its

Memoirs), "those given by Capt. Jacob at about the same date being added for comparison:—

	Mr. Hind in 1845.	Capt. Jacob in 1846.
Perihelion Passage	1699·26	1703·30
Projected place of Perihelion	8° 15	10° 0
Node	11 24	10 0
Angle between Perihelion and Node on Orbit	356 22	0 0
Inclination	43 14	43 17
Eccentricity	0·2405	0·300
Mean Annual Period	— 34′·163	— 33′·072
Semi-axis Major	6″·300	6″·30
Period	632·27 yrs.	653·1 yrs.

Capt. Jacob considered his results as only a rough approximation. Remembering that Sir John Herschel had obtained the period 253 years, while Smyth had obtained 240 years, we recognise the influence of recent observations, or rather of the progress of the motion of the component stars, in pointing to an increase of the orbit's extension. Mr. Wilson's result involves a somewhat startling advance in the same direction.

It may be added that the observations of Bradley and Pond give for the position-angle towards the close of the year 1720, 355° 53′.

The following measures are given by Dembowski in a recent number of the *Astronomische Nachrichten*:—

	Position-angle.	Distance.
1866·02	241°·07	5″·384
1870·237	240·2	5·30
·327	239·5	5·64
·349	239·6	5·41
·68	239·34	5·488
1871·185	238·1	5·50
·324	239·3	5·59

It is worthy of notice that the study of this fine double star first impressed on Sir W. Herschel's mind "a full conviction," to use his son's words, "of the reality of his long-cherished views on the subject of the binary stars."—Ed.

line of nodes nearly coincides with the axis major. I hope to find time in the summer to examine the orbit by analytical methods.

The arc at present described is not sufficient to allow of a reliable graphical solution.

If my orbit is correct, the angle of position will decrease towards the limit of 188°. It is now about 238°·12, according to the observations of Mr. Seabroke and myself, and a little less than this by the interpolating curve, about 237·85. Perhaps some observers would communicate their measures during the past four or five years.

It would seem that *Castor* is a difficult star to measure. Some of the observations taken about the year 1865 especially must be in error by at least 3°, even on the mean of several nights.

On the Nutoscope, an Apparatus for showing graphically the Phenomena of the Earth's Motion called Precession and Nutation. By Prof. Ch. V. Zenger.

(*Communicated by John Browning, Esq.*)

In the case of a rapidly-revolving solid, as the Earth's, round its axis, two things may take place, according as the mass of the solid body is or is not uniformly distributed round the axis of rotation. In the first case the axiswill steadily hold its position during the rotation, as is seen by rotating the top of a gyroscope. But if the motion of the rotating solid body is disturbed by a shock or overweight acting on one side, the axis of rotation will describe a cone and its apex a circle. This effect is produced by the attraction of the Sun and Moon on the Earth, conceived as a sphere rotating round its axis. The equatorial plane changes then periodically its points of intersection with the plane of the ecliptic, which we call the precession of the nodes.

In the second case, if the mass of the gyroscope is not equally distributed round the axis, and even this unequal distribution becomes changeable, which is practically done by putting on the axis of the rotating gyroscope a circular plate, with an excentric hole fitting loosely to the axis, the motion becomes more complicated, and the apex of the axis gets a double motion, a circular by the overweight acting as disturbing force on one side, and an elliptical produced by the change of position of that overweight, for the friction of the hole on the axis produces a retardation of the velocity of rotation of the circular plate. There will be described, as fig. 1 shows, a circle with a small ellipse revolving on its periphery, the centre of the ellipse being placed on it. The angle of the cone described thus will be changing periodically, and to a small extension, exactly as the complicated phenomenon of the earth's precession and nutation is due to the changing attraction by the Sun and Moon at

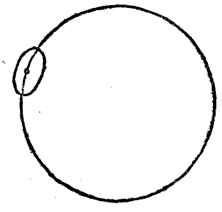
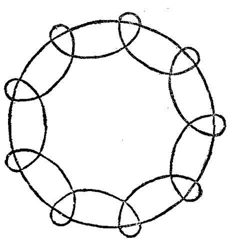


Fig. 1.

different distances and positions on the flattened or spheroidical earth-ball. The apex of the gyroscope in that condition represents, therefore, exactly the same kind of motion as that produced by the cumulated action of Sun and Moon on the rotating Earth; and this apparatus may, therefore, serve to show in a very plain and instructive manner the complicated astronomical phenomena of precession and nutation.

This is done by the apparatus that I call a Nutoscope. A very carefully-worked top of the known form is placed on a brass stand with a small spherical hole on its upper part, in which the sharply pointed axis of the rotating top is placed. The other end of its axis bears also a sharp point, that is slightly pressed on a blackened paper held by the hand in a quite horizontal position. It requires some practice to get a good drawing of the precessional and nutational curves by hand, and so I disposed the apparatus in such a way as to allow, by lowering with a micrometrical screw, a plate of paper fastened tightly on a brass ring moving along a cylindrical stand of brass near and perpendicularly to the axis of the top in its upright position. Another ring is fastened, with its plane parallel to the plane of the top in its upright position, the intersection of both planes giving the position of the nodes, the circular disk of the top representing the Earth's equator, and the plane of the ring the plane of the ecliptic. Giving the axis of the top by a fastened overweight an inclined position, the cone is described and the precession of the nodes shown on the periphery of the ring, and the apex of the top's axis describes on the blackened paper a circle.

Putting an additional changeable overweight, viz., the circular disk with the excentric hole on the top, the apex describes beautiful curved lines produced by the compound precessional and nutational motion, as shown in the adjoining diagram. The greater the weight of the circular disk, and the slower the rotation becomes, the larger become the elliptic motion and the more distended are the curved lines. The same effect is produced by the friction of the apex of the top axis, which can be conceived as a changeable disturbing force: it is, therefore, difficult to get a top that would not give those pretty curves of nutation of its axis.



A great variety of designs of these curves may be got by changing the form and weight of the disk, the ellipses may be got so narrow that they become only visible by aid of a microscope. The appearance of these curves may become in some degree a means to account for the equal distribution of the mass in such apparatus as gyroscopes, tops, &c.

If the velocity of rotation is rapidly diminishing by the resistance as friction, &c., the top's axis describes with a fastened overweight a spiral instead of a circle, and with a changeable overweight there is described a spiral line with an ellipse revolving with its centre on the spiral line.